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NATIONAL STANDARD

ANSI/CAN/UL/ULC 2039:2023

STANDARD FOR SAFETY

Flexible Connector Piping for Flammable and Combustible Liquids

Approved American National Standard
ANSI
ANSI/UL 2039-2023

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SCC FOREWORD

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UL Standard for Safety for Flexible Connector Piping for Flammable and Combustible Liquids, ANSI/CAN/UL/ULC 2039

Second Edition, Dated November 10, 2023

Summary of Topics

Harmonization of UL 2039 and ULC-S633 resulting in the new joint standard, ANSI/CAN/UL/ULC 2039, Standard for Flexible Connector Piping for Flammable and Combustible Liquids.

The new requirements are substantially in accordance with Proposal(s) on this subject dated June 10, 2022, October 7, 2022, and April 21, 2023.

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ANSI/UL 2039-2023

NOVEMBER 10, 2023

ANSI/CAN/UL/ULC 2039:2023

Standard for Flexible Connector Piping for Flammable and Combustible Liquids

First Edition – May, 2016

Second Edition

November 10, 2023

This ANSI/CAN/UL/ULC Safety Standard consists of the Second Edition.

The most recent designation of ANSI/UL 2039 as an American National Standard (ANSI) occurred on November 10, 2023. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page, Preface or SCC Foreword.

This Standard has been designated as a National Standard of Canada (NSC) on November 10, 2023.

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Preface

This is the Second Edition of ANSI/CAN/UL/ULC 2039, Standard for Flexible Connector Piping for Flammable and Combustible Liquids.

ULSE is accredited by the American National Standards Institute (ANSI) and the Standards Council of Canada (SCC) as a Standards Development Organization (SDO). ULC Standards is accredited by the Standards Council of Canada (SCC) as a Standards Development Organization (SDO).

This Standard has been developed in compliance with the requirements of ANSI and SCC for accreditation of a Standards Development Organization.

This ANSI/CAN/UL/ULC 2039 Standard is under continuous maintenance, whereby each revision is approved in compliance with the requirements of ANSI and SCC for accreditation of a Standards Development Organization. In the event that no revisions are issued for a period of four years from the date of publication, action to revise, reaffirm, or withdraw the standard shall be initiated.

Annex A is identified as Normative, as such, form mandatory parts of this Standard.

Annex B, identified as Informative, is for information purposes only.

In Canada, there are two official languages, English and French. All safety warnings must be in French and English. Attention is drawn to the possibility that some Canadian authorities may require additional markings and/or installation instructions to be in both official languages.

This joint American National Standard and National Standard of Canada is based on, and now supersedes, the First Edition of UL 2039 and the Fourth Edition of ULC-S633.

Comments or proposals for revisions on any part of the Standard may be submitted at any time. Proposals should be submitted via a Proposal Request in the Collaborative Standards Development System (CSDS) at https://csds.ul.com.

This Edition of the Standard has been formally approved by the Technical Committee (TC) on Containment Sumps For Flammable And Combustible Liquids, TC 2247.

This list represents the TC 2247 membership when the final text in this Standard was balloted. Since that time, changes in the membership may have occurred.

TC 2247 Membership

Name	Representing	Interest Category	Region
Brauksieck, James	US EPA	Government	USA
Dutton, John	Standards Individuals	General Interest	Canada
Edgecombe, Don	Alberta Petroleum Storage Systems Contractors Association	Commercial / Industrial User	Alberta, Canada

TC 2247 Membership Continued on Next Page

TC 2247 Membership Continued

Name	Representing	Interest Category	Region
Fisher, Laura	State Water Resources Control Board	AHJ	USA
Kane, Kristopher	OPW	Producer	USA
Koch, Wolf	Technology Resources International, Inc.	General Interest	USA
Legault, Pierre	Integrated Review Services – Consulting	Commercial / Industrial User	Canada
Lexvold, Jeff	Xerxes Corp	Producer	USA
Mailvaganam, Miles	M. Mailvaganam	General Interest	Canada
Mukai, Don	S Bravo Systems Inc.	Producer	USA
Nobile, John	Veeder-Root Co.	Producer	USA
Renkes, Robert	Fiberglass Tank & Pipe Institute	General Interest	USA
Prusko, Jeff	UL Standards & Engagement	Project Manager – Non voting	USA
Riegel, Roland	UL Solutions	Testing and Standards Org.	USA
Schneider, W	National Oilwell Varco	Producer	USA
Thompson, Jamie	Association for Petroleum & Explosives Administration	AHJ	UK
Wade, John	UL Standards & Engagement	TC Chair – Non-voting	Canada

International Classification for Standards (ICS): 75.200

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This Standard is intended to be used for conformity assessment.

The intended primary application of this Standard is stated in its scope. It is important to note that it remains the responsibility of the user of the standard to judge its suitability for this particular application.

CETTE NORME NATIONALE DU CANADA EST DISPONIBLE EN VERSIONS FRANÇAISE ET ANGLAISE

INTRODUCTION

1 Scope

1.1 This Standard sets forth the minimum requirements for cover primary, secondary, and coaxial types of flexible connector pipes intended for short length transfer and containment of the specific flammable and combustible liquids (or vapors thereof) identified in this Standard, at commercial (public) or fleet (private) automotive motor vehicle fueling stations or similar fuel dispensing applications, and piping systems for fuel supply of generators, burners or similar equipment.

1.2 Flexible connector pipes may be metallic, nonmetallic, or composite, but are limited to maximum 12 ft (3.65 m) lengths in nominal sizes up to 4 in (102 mm) as flexible transition components within fuel dispensing and/or vapor recovery piping systems, typically intended for use in the following automotive fueling station applications:

a) Underground use (below surface but accessible such as within chase piping) when connected to underground tanks or underground pipes with expected exposures to soil, water, and soil fluids;

b) Sump use (enclosed tank, transition or dispenser types) when connected to pumps, valves, monitors, or dispensing devices with expected exposures to soil, water, soil fluids, and occasional sunlight;

c) Aboveground use (above surface but with additional physical protection) when connected to aboveground tanks or aboveground pipes with expected exposures to soil, water, soil fluids, and sunlight.

1.3 Flexible connector pipes are intended for containment of automotive fuels and similar fuels or liquids under the expected use conditions, and exposures that have similar chemical, physical and material compatibility properties as represented in these requirements based on fuels formulated in accordance with 40 CFR Part 80, Regulation of Fuels and Fuel Additives, and meeting the following ASTM Fuel Specifications and blend limitations. Refer to Annex B (Informative) for a list of Standards on fuels and other liquids.

1.4 Products covered by this Standard are intended to be installed and used in accordance with:

a) In the United States:

1) Flammable and Combustible Liquids Code, NFPA 30,

2) Code for Motor Fuel Dispensing Facilities and Garages, NFPA 30A,

3) Uniform Fire Code, NFPA 1,

4) International Fire Code published by the International Fire Council, or

5) Other applicable federal and state regulations for piping.

b) In Canada:

1) National Fire Code of Canada;

2) CSA B139 Series, Installation Code for Oil-Burning Equipment; and

3) CCME PN 1326, Environmental Code of Practice for Aboveground and Underground Storage Tank Systems Containing Petroleum and Allied Petroleum Products.

1.5 These products are factory manufactured and intended for on-site field assembly, inspection, and leak testing for the specified applications and use conditions by qualified persons in accordance with the manufacturer's instructions and local requirements.

1.6 These products are intended to be periodically inspected and maintained for continued service, or taken out of service if necessary, by qualified persons in accordance with industry recommended practices and/or the manufacturer’s instructions.

1.7 These products have not been evaluated for use after natural disasters, fires or exposures to chemicals not representative of the test liquids or excessive physical damage beyond the expected assembly, installation and uses as identified in these requirements.

1.8 These products have not been evaluated for special use piping applications where exposed to heavy or continuous physical abuses, excessive mechanical stresses; or environments that are highly corrosive; or operate outside of the expected ambient use temperature range for significant times.

1.9 These requirements do not cover underground piping products for liquid fuels, which are found in the Standard for Nonmetallic Underground Piping for Flammable Liquids, UL 971 or Outline of Investigation for Metallic Underground Piping for Flammable Liquids, UL 971A, and ULC-S679, Standard for Metallic and Nonmetallic Underground Piping for Flammable and Combustible Liquids.

1.10 These requirements do not cover aboveground piping products for gaseous fuels (such as natural gas, liquefied petroleum gas, propane, butane, etc.), which are found in the Standard for Flexible Metallic Hose, UL 536.

1.11 These requirements do not cover fuel dispensing and vapor recovery hose, which are found in the Standard for Hose and Hose Assemblies for Dispensing Flammable and Combustible Liquids, UL 330, the Standard for Hose and Hose Assemblies for Use with Dispensing Devices for Dispensing Gasoline and Gasoline/Ethanol Blends with Nominal Ethanol Concentrations up to 85 Percent (E0-E85), UL 330A, or the Standard for Hose and Hose Assemblies for Use With Dispensing Devices Dispensing Diesel Fuel, Biodiesel Fuel, Diesel/Biodiesel Blends With Nominal Biodiesel Concentrations Up To 20 Percent (B20), Kerosene, and Fuel Oil, UL 330B.

2 General

2.1 Units of measurements

2.1.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

2.2 Referenced publications

2.2.1 Any undated reference to a code or standard appearing in the requirements of this Standard shall be interpreted as referring to the latest edition of that code or standard.

2.2.2 The documents shown below are referenced in the text of this Standard:

40 CFR Part 80n, *Regulation of Fuels and Fuel Additives*

ASTM A653/A653M, *Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process*

ASTM D396, *Standard Specification for Fuel Oils*

ASTM D471, *Test Method for Rubber Property – Effect of Liquids*

ASTM D975, *Standard Specification for Diesel Fuel Oils*

ASTM D1193, *Standard Specification for Reagent Water*

ASTM D3699, *Standard Specification for Kerosine*

ASTM D4806, *Standard Specification for Denatured Fuel Ethanol for Blending with Gasoline for Use as Automotive Spark-Ignition Engine Fuel*

ASTM D4814, *Standard Specification for Automotive Spark-Ignition Engine Fuel*

ASTM D5798, *Standard Specification for Ethanol Fuel Blends for Flexible-Fuel Automotive Spark-Ignition Engines*

ASTM D7467, *Standard Specification for Low Blend Biodiesel*

ASTM D7862, *Standard Specification for Butanol for Blending with Gasoline for Use as Automotive Spark-Ignition Engine Fuel*

ASTM G153, *Operating Enclosed Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials*

ASTM G155, *Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials*

CCME PN 1326, *Environment Code of Practice for Aboveground and Underground Storage Tank Systems Containing Petroleum and Allied Petroleum Products*

CGSB-3.2, *Heating Fuel Oil*

CGSB-3.3, *Kerosene*

CGSB-3.512, *Automotive Ethanol Fuel (E50-E85)*

CGSB-3.516, *Denatured Fuel Ethanol for Use in Automotive Spark-Ignition Fuels*

CGSB-3.522, *Diesel Fuel Containing Biodiesel (B6 – B20)*

CGSB -3.524, *Biodiesel (B100) for Blending in Middle Distillate Fuels*

CGSB-3.6, *Off-Road Diesel Fuel*

CSA B139 Series, *Installation Code for Oil-Burning Equipment*

CSA C22.2 No. 0.15, *Adhesive Labels*

International Fire Code

National Fire Code of Canada

NFPA 1, *Uniform Fire Code*

NFPA 30, *Flammable and Combustible Liquids Code*

NFPA 30A, *Code for Motor Fuel Dispensing Facilities and Garages*

UL 330, *Hose and Hose Assemblies for Dispensing Flammable and Combustible Liquids*

UL 330A, *Hose and Hose Assemblies for Use with Dispensing Devices for Dispensing Gasoline and Gasoline/Ethanol Blends with Nominal Ethanol Concentrations up to 85 Percent (E0-E85)*

UL 330B, *Hose and Hose Assemblies for Use With Dispensing Devices Dispensing Diesel Fuel, Biodiesel Fuel, Diesel/Biodiesel Blends With Nominal Biodiesel Concentrations Up To 20 Percent (B20), Kerosene, and Fuel Oil*

UL 536, *Flexible Metallic Hose*

UL 797, *Electrical Metallic Tubing*

UL 969, *Marking and Labeling Systems*

UL 971, *Nonmetallic Underground Piping for Flammable Liquids*

UL 971A, *Outline of Investigation for Metallic Underground Piping for Flammable Liquids*

ULC S679, *Metallic and Nonmetallic Underground Piping for Flammable and Combustible Liquids*

3 Glossary

3.1 For the purposes of this Standard, the following definitions apply.

3.1 ABOVEGROUND – Physically located on or above the surface layer of earth; can be in contact with/exposed to soil, water, air, and sunlight. Aboveground can include above grade enclosures or other means to reduce exposure to physical damage and the environmental conditions noted.

3.2 COAXIAL CONNECTOR PIPE (Coaxial) – A double wall connector pipe construction consisting of integral primary and secondary connector pipes with a defined interstitial space that provides fluid communication and monitoring capabilities.

3.3 FLEXIBLE CONNECTOR PIPE (Connector Pipe or Flex Connectors) – A maximum 12 ft (3.65 m) long cylindrical thin-walled structure with integral end fittings designed for flexibility in containing and conveying flammable and combustible liquids in applications identified in the intended scope of use. Connector pipe types include primary, secondary and coaxial constructions.

3.4 FUELS – Typically those liquids identified in Annex B (Informative) that are dispensed in commercial or fleet motor vehicle fueling stations for use in automotive engines (internal combustion or compression ignition).

3.5 PRIMARY CONNECTOR PIPE (Primary) – A single wall connector pipe construction intended to contain and convey the liquid flowing in a piping system under normal use. Primary connector pipe is intended for long term continuous contact with the liquid.

3.6 QUALIFIED PERSON – A worker specifically trained by the manufacturer to perform proper assembly and installation of its piping systems in the field in accordance with the specified instructions. The qualified person is not required to be an employee of the manufacturer.

3.7 SECONDARY CONNECTOR PIPE (Secondary) – A single wall connector pipe construction intended to surround the primary, contain the liquid under abnormal conditions (such as primary rupture), and provide fluid communication and monitoring capabilities.

3.8 SIZE (Pipe Size or Fitting Size) – Nominal or trade dimensions (inches or mm) of connector pipe and fittings based on inside diameters or thread. *NOTE: Nominal or trade sizes may not be equivalent to the actual measurements.*

3.9 SUMP – Accessible atmospheric enclosure located underground, typically below a dispenser, above a tank, or at grade between tanks and dispensers, and designed to house pipe, connections, equipment and contain spills.

3.10 SWIVEL JOINT – A connection or joint designed to allow frequent rotational movement of the pipe during normal functional use.

3.11 UNDERGROUND – Physically located below the surface layer of earth either in contact with soil and soil fluids (direct burial) or routed in a secondary or chase pipe (indirect burial).

3.12 UNION JOINT – A connection or joint designed to allow rotational movement of the pipe only during assembly, installation or maintenance.

CONSTRUCTION

4 General

4.1 Connector pipe is permitted to be constructed from any combination of materials, but shall be flexible with a bend radius of 2 ft (610 mm) or less, and shall be capable of field assembly and installation without the use of special equipment or tools unless these are specified by the manufacturer.

4.2 The total connector pipe length (pipe and fittings) shall not exceed 12 ft (3.65 m). The diameter of connector piping shall not exceed standard nominal trade sizes beyond a 0.5 – 4.0 in (12.5 to 102 mm) range.

4.3 Primary connector pipe and the primary of a coaxial connector pipe shall be rated at least 50 psig (345 kPa). Secondary connector pipe and the secondary of a coaxial connector pipe shall be rated at least 50 psig (345 kPa).

4.4 Connector piping shall be supplied with end fittings that are capable of assembly to fixed pipe or fueling components, such as threaded fittings, or bolted flanges, or weld/bond joints. Moving swivel and union joints are permitted. All pipe threads shall be NPT, NPTF, BSPT, BSPP or similar common trade types. All bolts, gaskets, and other components shall be supplied with the product.

4.5 All materials used in the construction of connector pipe and fittings shall be suitable for their intended use locations with respect to normal (expected use within marked ratings) and abnormal (reasonable foreseeable misuse) conditions in accordance with the required performance tests described in this Standard.

4.6 Nonmetallics (polymers, elastomers, ceramics, etc.) used in the construction of connector pipe and fittings shall be evaluated for long-term exposure compatibility to air, soil, water, ultraviolet light, and internal and external fluids within the expected ambient use temperature range for underground, sump, and/or aboveground use per 1.2.

4.7 Metallics used in the construction of connector pipe and fittings shall be inherently corrosion resistant (such as stainless steel, aluminum, brass), plated, or coated per 4.8, or evaluated for equivalent corrosion resistance per 4.9. All metals shall comply with all applicable requirements in this Standard.

4.8 Corrosion resistant coatings or platings provided on metals (such as plain carbon steel) shall be minimum designation Z275 (G90) (minimum 40 % zinc galvanizing on all sides) per ASTM A653/A653M.

4.9 Equivalent alternate corrosion protection methods shall be determined by an evaluation of coating or plating in accordance with the method in UL 797, except with the visual corrosion comparison between benchmark Z275 (G90) and alternate protection conducted after exposures to Table 11.1.

PERFORMANCE

5 General

5.1 Representative production samples of each connector pipe type or component shall be subjected to the appropriate Performance Tests with sample variations of connector pipe type, design material, and size as specified in each test method. Special samples combining different variations, such as end fitting, joint and gasket options are permitted in order to reduce the total number of samples, provided they are representative of regular design, material and production methods.

5.2 Critical dimensions (such as diameter, thickness, corrugation, out of round, threads, braids, etc.) of 10 random samples of each pipe type, construction, and size, shall be measured before other tests are conducted. All sample dimensions shall be within the manufacturer's quality control specifications, and:

a) Thickness of each sample shall be within ±15 % of the test set average; and

b) Diameters of each sample shall be within ±10 % of the test set average.

5.3 The formula for calculated hoop stress, specified below, may be used to determine "worst case" sizes to reduce the number of specimens when testing homogeneous mono-layer pipe in all nominal sizes for a product range. In addition, analyzed data from the 6 Short Term Pressure Test sequence may be used to determine worst case samples for other specific tests.

$$S = \frac{P(D - t)}{2t}$$

in which:

S is hoop stress (psi or kPa),

P is the breakdown pressure (psi or kPa) per 6.4,

D is the average outside diameter (in or mm) per 5.2, and

t is the minimum wall thickness (in or mm) per 5.2.

Exception: The above formula may be modified or another engineering-based analysis used for multilayer and non-homogeneous pipe to determine the worst case size in a product range.

5.4 Representative sample sizes for the Performance Tests are defined as either:

a) "ALL" for all nominal or trade sizes within a manufacturer's product range;

b) "WC" for worst case sizes per maximum average hoop stress per 5.3, or other analytical method; or

c) As otherwise indicated in the specific test.

5.5 Representative worst case sample quantities for Long Term Compatibility and Permeation Tests shall be based on the minimum thickness of interior or exterior materials in contact with the test fluids, and other critical design parameters such as end fitting, joint or gasket options, location ratings, pressure ratings and bend radius.

5.6 New samples may be used for each test except for the sequence of the Short Term Pressure Tests (Leakage per 6.2, Hydrostatic per 6.3 and Breakdown per 6.4), which shall use the same sample and test equipment at successively higher pressures. If acceptable to the manufacturer, the same sample may be used for multiple tests.

5.7 Assembly of all connector piping samples shall be conducted by a qualified person using manufacturer-supplied components in accordance with the manufacturer's instructions (thread torque, crimp pressure or other critical assembly parameters). If multiple methods of connecting pipe and fittings are used, each shall be evaluated.

5.8 Damage shall be determined by visual examination with the naked eye from arms length (approximately 3 ft (914 mm), of any critical sample or part after testing. The following items are examples of complying and noncomplying results; however, final determination of damage characteristics and results shall be based on manufacturer input before testing or qualified by a specific test:

a) Metallic Piping and Fittings – discoloration or minor dimensional change are compliant, but excessive permanent deformation, crazing, cracking, splitting, braid failure, kinking, and excessive corrosion or loss of corrosion protection are noncompliant examples;

b) Nonmetallic Flexible Piping and Fittings – discoloration or minor dimensional change are compliant, but major dimensional changes, cracking, splitting, bulging, collapse, and delamination are noncompliant examples.

5.9 Unless otherwise indicated in a specific test method, all tests shall be conducted with working fluids at 21 ±6 °C (70 ±11 °F) or at normal ambient temperatures between 17 °C and 29 °C (65 °F and 85 °F) and 50 ±20 %) RH. All pressures shall be measured with respect to gauge (psig or kPa).

5.10 Unless otherwise indicated in a specific test method, hydrostatic tests shall be conducted with water and aerostatic tests shall be conducted with air (or other inert gasses). In either case, precautions shall be used to prevent personal injury.

5.11 For each of the eight groups of tests described in this section, the individual tests contained in the subsections shall be performed in the sequence given, unless otherwise specified. For example, in Section 7, Vacuum Tests, the sequence shall be Static Vacuum Test followed by Cyclic Vacuum Test.

6 Short Term Pressure Tests

6.1 General

6.1.1 Sets of three 3 ft (914 mm) lengths of each type, construction, and size of connector pipe shall be tested in a continuous sequence on the same sample, in accordance with the:

a) Leakage Test per 6.2;

b) Hydrostatic Test per 6.3; and

c) Breakdown Test per 6.4.

6.1.2 All connector pipes evaluated are to be filled with water (with or without antifreeze as required) before applying the test pressures hydrostatically. The test sequence shall start at 0 psig (0 kPa) and gradually increase at:

a) 10 ±5 psig/min (69 ±35 kPa/min) for pipe rated less than 50 psig (345 kPa), or

b) 100 ±20 psig/min (690 ±138 kPa/min) for pipe rated 50 psig (345 kPa) or more.

6.1.3 There shall be at least a 5 min pause at each test level (except when completing the Breakdown Test, 6.4) when the samples are to be visually examined for damage and leakage. Filling and sealing the primary of a coaxial connector pipe is permitted when testing the secondary to prevent implosion.

6.1.4 All samples used for the Short Term Pressure tests shall be tested hydrostatically. Alternatively, an aerostatic method or combined hydrostatic/aerostatic method may be used if found superior to the hydrostatic method to accurately determine leakage. Leakage is to be detected by visual examination with the aid of dyes, leak solution, blotting paper, bubble submersion, or any other accurate and repeatable method.

6.2 Leakage test

6.2.1 Connector pipe of all types, constructions, and sizes shall be subjected to the Leakage Test while at the following test temperatures for at least 1 h:

a) A low temperature of -30 ±2 °C (-22 ±3.6 °F),

b) Lab temperature range of 22 ±2 °C (72 ±3.6 °F),

c) High temperature of 50 ±2 °C (122 ±3.6 °F).

6.2.2 The Leakage test pressure shall be at least twice the rated pressure, and there shall be no leakage or any noncomplying damage (see 5.8) while the samples are pressurized.

6.3 Hydrostatic test

6.3.1 Following the Leakage test, 6.2, connector pipe of all types, constructions and sizes shall be subjected to the Hydrostatic test while at the following test temperatures for at least 1 h:

a) A low temperature of -30 ±2 °C (-22 ±3.6 °F),

b) Lab temperature range of 22 ±2 °C (72 ±3.6 °F),

c) High temperature of 50 ±2 °C (122 ±3.6 °F).

6.3.2 The hydrostatic test pressure shall be at least five times the rating. There shall be no leakage (but damage is acceptable) while the samples are pressurized.

6.4 Breakdown test

6.4.1 Following the Hydrostatic test, 6.3, connector pipe of all types, constructions and sizes shall be subjected to the Breakdown test while at the following test temperatures for at least 1 h:

a) A low temperature of -30 ±2 °C (-22 ±3.6 °F),

b) Lab temperature range of 22 ±2 °C (72 ±3.6 °F),

c) High temperature of 50 ±2 °C (122 ±3.6 °F).

6.4.2 The test pressure is to be gradually increased at the rates specified in (6.1.2) until severe leakage, rupture or burst occurs. The type and location of breakdown or other significant damage shall be recorded along with the breakdown pressure for use in comparing with retention values in this and other tests.

6.4.3 The average breakdown pressure values for high temperature and low temperature sample sets shall not be less than 10 times the rated pressure, or 70 % of the average lab temperature sample set. The average breakdown pressure values of each temperature set shall not deviate more than ±20 % from the average of all three temperature sets.

7 Vacuum Tests

7.1 General

7.1.1 Sets of three 3 ft (914 mm) lengths of each type and construction in worst-case sizes of connector pipe specified in each method shall be tested in accordance with:

a) Static vacuum test per 7.2, and

b) Cyclic vacuum test per 7.3.

7.1.2 Vacuum Tests shall use air as the test fluid, and unless otherwise specified, the leakage test shall be conducted using water as the test fluid. Leakage shall be detected by visual examination with or without dyes, leak solution, blotting paper, bubble submersion or any other accurate and repeatable method.

7.2 Static vacuum test

7.2.1 Each type and construction of connector pipe in worst case samples shall be subjected to the Static Vacuum Test while operating at a lab temperature of 22 ±2 °C (72 ±3.6 °F).

7.2.2 All samples shall be subjected to a static vacuum of at least 25 in (635 mm) Hg for 10 min followed by a repeat Leakage Test per 6.2, and Breakdown Test per 6.4.

7.2.3 The samples shall not be damaged after the static vacuum or leak after pressurizing. The average of the breakdown pressure values for each sample set shall be at least 250 psig (1724 kPa) for primary, and/or 200 psig (1379 kPa) for secondary, with the average of the breakdown pressure values being at least 10 times the rated pressure, or 70 % of the as-received lab temperature breakdown pressure, whichever is greatest.

7.3 Cyclic vacuum test

7.3.1 Samples shall be subjected to the Cyclic Vacuum Test while operating at a lab temperature of 22 ±2 °C (72 ±3.6 °F).

7.3.2 All samples shall be subjected to alternating pressure cycles (min 1 s at 0 and min 5 s at rated vacuum) applied at 4 to 6 cycles/min for 250,000 cycles followed by a repeat Leakage test per 6.2, and Breakdown test per 6.4.

7.3.3 The samples shall not be damaged after cyclic vacuum or leak after pressurizing. The average of the breakdown pressure values for each sample set shall be at least 250 psig (1724 kPa) for primary and/or 200 psig (1379 kPa) for secondary, with the average at least 10 times the rated pressure, or 70 % of the as-received lab temperature breakdown pressure.

8 Physical Abuse Tests

8.1 General

8.1.1 Samples of each connector pipe type, construction, and size as indicated in each method shall be tested in accordance with the following:

a) Drop test per 8.2 for all pipes,

b) Impact test per 8.3 for all pipes,

c) Puncture test per 8.4 for all pipes,

d) Fitting torque test per 8.5 for all pipes,

e) Pipe torque test per 8.6 for all pipes,

f) Tension test per 8.7 for all pipes,

g) Compression test per 8.8 for all pipes, and

h) Bending test per 8.9 for all pipes.

8.1.2 After each Physical Abuse Test, all samples shall be subjected to the Leakage Test, per 6.2 and Breakdown Test per 6.4, at lab temperature only. Water shall be used as the test fluid to determine compliance. Leakage shall be detected by visual examination with or without dyes, leak solution, blotting paper, bubble submersion or any other accurate and repeatable method.

8.2 Drop test

8.2.1 One set of three 6 ft (1.83 m) samples of each connector pipe in worst case sizes shall be subjected to 4 ft (1.22 m) drops at 50 ±2 °C (122 ±3.6 °F) and -30 ±2 °C (-22 ±3.6 °F) [or -40 ±2 °C (-40 ±3.6 °F) for an optional "Severe LT" (Severe Low Temperature) rating], each followed by a visual exam.

8.2.2 All samples shall be dropped on a flat concrete surface after reaching the specified temperatures, with the drop height measured from the sample target area. One sample shall be dropped three times per temperature, at target areas of the pipe center, end fitting, and pipe near the fitting respectively. Adjusting the pipe orientation to hit the targeted areas is permitted.

8.2.3 The samples shall not be damaged after dropping or leak after pressurizing. The average of the breakdown pressure values for each sample set shall be at least 250 psig (1724 kPa) (primary), and/or 200 psig (1379 kPa) (secondary), with the average of the breakdown pressure values being at least 10 times the rated pressure, or 70 % of the as-received lab temperature breakdown pressure, whichever is greatest.

8.3 Impact test

8.3.1 One set of three 6 ft (1.83 m) samples of each connector pipe in worst case sizes shall be subjected to 6 ft-lbf (8.1 J) impacts at 50 ±2 °C (122 ±3.6 °F) and -30 ±2 °C (-22 ±3.6 °F) [or -40 ±2 °C (-40 ±3.6 °F) for an optional "Severe LT" (Severe Low Temperature) rating], each followed by a visual exam.

8.3.2 All samples shall rest on a hard surface and be impacted with a 2 in (51 mm) OD steel ball after reaching the specified temperatures, with the impact height measured from sample target area. One sample shall be impacted three times per temperature, at target areas of the pipe center, end fitting, and pipe near the fitting respectively. Use of a ball guide to hit the target areas is permitted.

8.3.3 The samples shall not be damaged after impacting or leak after pressurizing. The average of the breakdown pressure values for each sample set shall be at least 250 psig (1724 kPa) (primary), and/or 200 psig (1379 kPa) (secondary), with the average of the breakdown pressure values being at least 10 times the rated pressure, or 70 % of the as-received lab temperature breakdown pressure, whichever is greatest.

8.4 Puncture test

8.4.1 One set of three 3 ft (914 mm) samples of each connector pipe in worst case sizes shall be subjected to 15 lb (6.8 kg) point load for 1 h at 50 ±2 °C (122 ±3.6 °F) and -30 ±2 °C (-22 ±3.6 °F), each followed by a visual exam.

8.4.2 All samples shall rest on a hard surface, and the point load shall be applied at the pipe center perpendicular to the surface through a 0.20 in (5.0 mm) diameter steel shaft with a 0.04 in (1.0 mm) diameter tip and 30° edge. New locations shall be tested at each temperature.

8.4.3 The sample containment wall shall not be punctured or leak after pressurizing. The average of the breakdown pressure values for each sample set shall be at least 250 psig (1724 kPa) (primary), and/or 200 psig (1379 kPa) (secondary), with the average of the breakdown pressure values being at least 10 times the rated pressure, or 70 % of the as-received lab temperature breakdown pressure, whichever is greatest.

8.5 Fitting torque test

8.5.1 One set of three 3 ft (914 mm) samples of each connector pipe in worst case sizes with threaded fittings or flange bolts shall each be connected to mating Schedule 40 steel pipe or bushing at 1.5 times the manufacturer's recommended torque, with one end of each sample assembled at 50 ±2 °C (122 ±3.6 °F) and -30 ±2 °C (-22 ±3.6 °F) respectively.

8.5.2 The samples shall not leak when subjected to test torques or pressures. The average of the breakdown pressure values for each sample shall be at least 250 psig (1724 kPa) (primary), and/or 200 psig (1379 kPa) (secondary), with the average of the breakdown pressure values being at least 10 times the rated pressure, or 70 % of the as-received lab temperature breakdown pressure, whichever is greatest.

8.6 Pipe torque test

8.6.1 One set of three 3 ft (914 mm) samples of each connector pipe in worst case sizes shall each be connected to a mating Schedule 40 steel pipe or bushing. The longitudinal pipe axis shall then be twisted 90° through the end fittings for 1 h at 50 ±2 °C (122 ±3.6 °F) and -30 ±2 °C (-22 ±3.6 °F) respectively.

8.6.2 The samples shall not leak when subjected to test torques or pressures. The average of the breakdown pressure values for each sample shall be at least 250 psig (1724 kPa) (primary), and/or 200 psig (1379 kPa) (secondary), with the average of the breakdown pressure values being at least 10 times the rated pressure, or 70 % of the as-received lab temperature breakdown pressure, whichever is greatest.

8.7 Tension test

8.7.1 One set of three 3 ft (914 mm) samples of each connector pipe in worst case sizes shall be connected to mating fittings. The longitudinal pipe axis shall then be subjected to a 500 lb (227 kg) tension load applied through the end fittings for 1 min at 50 ±2 °C (122 ±3.6 °F) and -30 ±2 °C (-22 ±3.6 °F) respectively.

8.7.2 The samples shall not leak when subjected to test loads or pressures. The average of the breakdown pressure values for each sample shall be at least 250 psig (1724 kPa) (primary), and/or 200 psig (1379 kPa) (secondary), with the average of the breakdown pressure values being at least 10 times the rated pressure, or 70 % of the as-received lab temperature breakdown average breakdown pressure, whichever is greatest.

8.8 Compression test

8.8.1 One set of three 3 ft (914 mm) samples of each connector pipe in worst case sizes shall be connected to mating fittings. The pipe center and end sleeve shall then be subjected to separate 500 lb (227 kg) compression loads applied through 3.0 in (7.6 cm) wide flat metal plates for 1 min at 50 ±2 °C (122 ±3.6 °F) and -30 ±2 °C (-22 ±3.6 °F), respectively.

8.8.2 The samples shall not leak when subjected to test loads or pressures. The average of the breakdown pressure values for each sample shall be at least 250 psig (1724 kPa) (primary), and/or 200 psig (1379 kPa) (secondary), with the average of the breakdown pressure values being at least 10 times the rated pressure, or 70 % of the as-received lab temperature breakdown pressure, whichever is greatest.

8.9 Bending test

8.9.1 One set of three 3 ft (914 mm) samples of each connector pipe in worst case sizes shall be connected to mating fittings, then subjected to bending at 1.5 times below the manufacturer's marked minimum radius for at least 1 min at 50 ±2 °C (122 ±3.6 °F) and -30 ±2 °C (-22 ±3.6 °F), respectively. Mandrels are not permitted to maintain the pipe arc.

8.9.2 The samples shall not kink or leak when subjected to the bend arc or pressures. The average of the breakdown pressure values for each sample shall be at least 250 psig (1724 kPa) (primary), and/or 200 psig (1379 kPa) (secondary), with the average of the breakdown pressure values being at least 10 times the rated pressure, or 70 % of the as-received lab temperature breakdown pressure, whichever is greatest.

9 Cyclic Use Tests

9.1 General

9.1.1 Sets of three samples of each connector pipe type, construction, and size as indicated in each method shall be tested in accordance with the:

a) Vibration test per 9.2 for all pipe types;

b) Surge test per 9.3 for all pipe types;

c) Flex test per 9.4 for all pipe types; and

d) Swivel test per 9.5 for all pipe types with swivel joints.

9.1.2 After each Cyclic Use test, all samples shall be subjected to the Leakage Test per 6.2 and Breakdown Test per 6.4 at lab temperature only. Water shall be used as the test fluid to determine compliance. Leakage shall be detected by visual examination with or without dyes, leak solution, blotting paper, bubble submersion, or any other accurate and repeatable method.

9.2 Vibration test

9.2.1 One set of three 3 ft (914 mm) long samples of each connector pipe in worst case sizes shall be connected at end fitting(s) to suitable test equipment, then subjected to a continuous vibration per 9.2.2 while at rated pressure.

9.2.2 All samples shall be tested at a 1/2 cycle amplitude of 0.075 ±0.005 in (1.91 ±0.13 mm) for a total displacement of 0.15 ±0.02 in (3.81 ±0.05 mm) at a frequency of 950 ±50 cycles/min for 300 h. Samples shall be filled with water to rated pressure, sealed, then fixed at the end(s) on the vibration table in different orientations, so only one plane of motion is possible per sample:

Sample 1 – (X plane) Longitudinal axis parallel to displacement;

Sample 2 – (Y plane) Longitudinal axis perpendicular to displacement; and

Sample 3 – (Z plane) Pipe at minimum bend radius with the upward arc perpendicular to displacement (both ends may be fixed).

9.2.3 The samples shall not be damaged after vibration or leak after pressurizing. The average of the breakdown pressure values for each sample shall be at least 250 psig (1724 kPa) (primary) and/or 200 psig (1379 kPa) (secondary), with the average of the breakdown pressure values being at least 10 times the rated pressure, or 70 % of the as-received lab temperature breakdown pressure, whichever is greatest.

9.3 Surge test

9.3.1 One set of three 3 ft (914 mm) long samples of each primary connector pipe or primary of a coaxial pipe in worst case sizes shall be connected at end fitting(s) to suitable test equipment, then subjected to a cyclic pressure surge per 9.3.2.

9.3.2 The primary of each sample shall be subjected to 200,000 cycles of hydrostatic pressures between 15 ±10 psig (103 ±69 kPa) and 250 psig (1724 kPa) at 4 to 10 cycles/min, with approximately 1 s at the low and high cycle points. Samples shall be filled with water, sealed, and coupled to the test apparatus under the different orientations and forces below:

Sample 1 – 20 lbf (89 N) tension applied to the straight pipe length;

Sample 2 – 20 lbf (89 N) compression applied to the straight pipe length; and

Sample 3 – While bent at the manufacturers minimum bend radius.

9.3.3 The samples shall not be damaged after surge pressurization or leak after pressurizing. The average of the breakdown pressure values for each sample shall be at least 250 psig (1724 kPa) (primary) and/or 200 psig (1379 kPa) (secondary), with the average of the breakdown pressure values being at least 10 times the rated pressure, or 70 % of the as-received lab temperature breakdown pressure, whichever is greatest.

9.4 Flex test

9.4.1 One set of three 3 ft (914 mm) long samples of each connector pipe in worst case sizes shall be connected at end fitting(s) to suitable test equipment, then subjected to a cyclic force per 9.4.2.

9.4.2 All samples shall be subjected to 50 cycles of flexing the pipe at a rate between 6 and 10 cycles/min over the full range of motion to be evaluated. Samples shall be filled with water, sealed, fixed at one end under the different orientations and subjected to the cycles below:

Sample 1 – ±0.5 in (12.7 mm) displacement of the pipe length;

Sample 2 – ±30° twisting perpendicular to the pipe length; and

Sample 3 – ±45° arc at the manufacturer's minimum bend radius.

9.4.3 The samples shall not be damaged after flexing or leak after pressurizing. The average of the breakdown pressure values for each sample shall be at least 250 psig (1724 kPa) (primary), and/or 200 psig (1379 kPa) (secondary), with the average of the breakdown pressure values being at least 10 times the rated pressure, or 70 % of the as-received lab temperature breakdown pressure, whichever is greatest.

9.5 Swivel joint test

9.5.1 One set of three 3 ft (914 mm) long samples of each swivel type connector pipe with functional joint in worst case sizes shall be connected at end fitting(s) to suitable test equipment, then be subjected to a cyclic joint swivel per 9.5.2.

9.5.2 All samples shall be subjected to 100,000 cycles of working the swivel joint at a rate of 10 – 30 cycles/min over the full joint range, but not less than 180°. Samples shall be filled with water, sealed, and fixed at one end under the different orientations and forces below:

Sample 1 – 20 lbf (89 N) tension applied to the joint;

Sample 2 – 20 lbf (89 N) compression applied to joint; and

Sample 3 – While bent at the manufacturer's minimum bend radius.

9.5.3 The samples shall not be damaged after swiveling or leak after pressurizing. The average of the breakdown pressure values for each sample shall be at least 250 psig (1724 kPa) (primary), and/or 200 psig (1379 kPa) (secondary), with the average of the breakdown pressure values being at least 10 times the rated pressure, or 70 of the as-received lab temperature breakdown pressure, whichever is greatest.

10 Short-Term Compatibility Tests

10.1 General

10.1.1 Samples of each connector pipe type, construction, and size as indicated in each method shall be subjected to the following:

a) UV exposure test per 10.2 for nonmetallic pipe;

b) Metallic stress test per 10.3 for metallic fittings;

c) Nonmetallic stress test per 10.4 for nonmetallic pipe.

10.1.2 Representative "worst case" samples may be used for pipe and fittings if materials, thickness, and process are consistent between nominal sizes or fitting types (straight, elbow or tee).

10.2 UV exposure test

10.2.1 Two 12 in (305 mm) samples of connector pipe designed with exposed nonmetallic exterior materials in representative worst case sizes, shall be subjected to either of the test methods below at a cycle rate of 17 min light and 3 min water. One sample shall be straight and the other bent to the manufacturer's minimum bend radius.

a) 360 h (underground rating), 540 h (sump rating) or 720 h (aboveground rating) using the Apparatus and Procedures of Test Method 1, per ASTM G153; or

b) 500 h (underground rating), 750 h (sump rating) or 1000 h (aboveground rating) using the Apparatus and Procedures of Test Method A, per ASTM G155.

10.2.2 Following the UV exposure, samples shall be examined for damage and then subjected to a repeat Leakage Test per 6.2 and Breakdown Test per 6.4.

10.2.3 The samples shall not be damaged after UV exposure or leak after pressurizing. Each breakdown pressure value shall be at least 250 psig (1724 kPa) (primary), and/or 200 psig (1379 kPa) (secondary), with the average at least 70 of the as-received lab temperature breakdown pressure.

10.3 Metallic stress crack test

10.3.1 For connector pipe constructed with threaded end fittings or bolted flanges containing at least 15 % zinc (excluding platings), one worst case fitting in all sizes shall be exposed to a moist ammonia-air mixture of minimum 20 US fl oz (600 mL) of 0.94 spg aqueous ammonia for 10 days at 34 °C (95 °F) in a heated water bath or oven.

10.3.2 All fitting samples shall be grease-free, assembled with steel plugs at the manufacturer's recommended torque, and positioned above the ammonia in a suitable container.

10.3.3 Following the exposure, the samples are to be visually examined without magnification tools. The fittings shall not show any evidence of cracking, crazing, or similar damage.

10.4 Nonmetallic stress crack test

10.4.1 For connector pipe constructed with polyethylene (any type or percentage blend), one 12 in (305 mm) long section of worst case pipe in all sizes shall be exposed to a 10 % poly-oxyethylated nonylphenol (Type CO-630 IGEPAL) water solution for 180 h at 60 ±2 °C (140 ±3.6 °F) in a heated water bath or oven.

NOTE : IGEPAL is a Trade Mark of Rhodia Operations.

10.4.2 All pipe samples shall be cleaned, bent to the manufacturer's minimum bend radius, and immersed in the IGEPAL test solution.

10.4.3 Following the exposure, the samples are to be visually examined without magnification tools. The pipe shall not show any evidence of cracking, crazing, or similar damage.

11 Long-Term Compatibility Tests

11.1 Sets of at least three samples in 18 in (457 mm) lengths of all connector pipe types and constructions in representative worst case sizes for each exposure liquid and time period shall be subjected to the liquids and exposures specified in Table 11.1 and Table 11.2 to simulate long term

compatibility to intended fuels and expected soil and environmental fluids. No materials, regardless of chemical resistance or corrosion resistance, shall be exempt from this test.

Table 11.1
Compatibility Test Liquids

External soil and environmental test fluids at 40 °C (104 °F)	Flammable and combustible test fuels at 40 °C (104 °F)
pH 3.0 sulfuric acid 1 % hydrochloric acid[a] 1 % nitric acid[a] pH 12 sodium hydroxide pH 10 sodium carbonate/bicarbonate[b]	Required Test Liquids F75/B25a[e] F25/B75a[d] C75/E25a[e] C15/E85a[e]
Saturated sodium chloride Distilled water[c]	Optional Test Liquids as Requested by the Manufacturer, such as: B100a, Fuel Oil #6 @xx°C, M100, E100, or other flammable and combustible liquids[f]
Air at 70 °C only for connectors with nonmetallic components	
NOTES 1 – Test parameters, such as temperature and concentrations of media, are increased in severity over those of normal operating conditions to obtain observable deterioration in a reasonable time period. This accelerated test does not give a direct correlation with service performance. However, this method of testing yields comparative data on which to evaluate the product. 2 – ASTM Reference Fuel C and F are described in ASTM D471. Fuel C is a 50/50 mixture of Iso-Octane and Toluene. Fuel F shall be Grade D2 S15.	
[a] Percentage by weight. [b] A pH 10 is obtained by mixing 10.6 grams per liter of sodium carbonate and 8.4 grams per liter of sodium bicarbonate. A pH meter shall be used to measure and adjust ratio of sodium carbonate to sodium bicarbonate to obtain a pH of 10. [c] Distilled water having a maximum total matter of 2.0 ppm and a maximum electrical conductivity of 5.0 µΩ/cm at 25 °C (77 °F), as described for Type IV grade reagent water in the ASTM D1193. [d] The chemical formulation of UL B100 aggressive biodiesel as a test fuel component of F75/B25a can be found in Annex A. B = UL B100 and F = ASTM Ref Fuel F. [e] The chemical formulation for aggressive alcohols used in mixing C75/E25a and C15/E85a is found in Annex A. C = ASTM Ref Fuel C and E = Ethanol. [f] Other flammable and combustible liquids (for which the test fuels in Annex B are not considered to be sufficient or applicable) that can be demonstrated or deemed to be compatible with the flexible connector pipe materials as determined by the certifier may be added to a manufacturer's listing.	

11.2 The exposure time period for each compatibility test liquid sample set at the elevated temperature shall be 120 d. Additional time periods requested by the manufacturer to evaluate sample preparation effectiveness, or to obtain analytical prediction data are not prohibited.

11.3 Prior to testing, the samples are to be preconditioned (at lab temperature only) to simulate expected transport, assembly, installation, and use physical abuses by subjecting the connector pipe sequentially to the following tests:

a) Drop test per 8.2;

b) Impact test per 8.3;

c) Puncture test per 8.4; and

d) Bending test per 8.9, except at the rated minimum bend radius.

Exception: Drop, impact, and puncture preconditioning may be waived if there is no evidence of abuse on the design after initial test results, verified by:

a) No evidence of noncompliant damage after the test, and

b) At least 10 times the rated pressure, or 80 % average breakdown value retention.

11.4 All samples shall have surfaces exposed as specified in Table 11.2. Except air oven, all samples shall be exposed to both liquid and vapor phases by filling or immersing approximately half the sample with/in the test liquids, and vertically storing during the exposure time. End plugs or caps and sealing materials shall be compatible with the test liquid(s) to provide leak-tight containment.

NOTE: samples may be periodically checked for loss of liquid (absorption or permeation), and topped off if necessary to maintain the original levels.

Table 11.2
Exposed Surfaces for Test Samples

Connector pipe type	Test fuels	Soil fluids	Air oven
Primary	All	P E	All
Secondary	All	S E	All
Coaxial	All	S E	All
NOTES Pipe containment type – P = Primary and S = Secondary Exposed surfaces – I = Interior, E = Exterior and all surfaces Samples may be periodically checked for loss of liquid (absorption or permeation), and topped off if necessary to maintain the original levels.			

11.5 All sample exposures specified in Table 11.2 are to be maintained over the entire test time period at the indicated temperatures ±2 °C (±3.6 °F) using a water bath, ambient room, or equivalent, for all liquid exposures and an air circulating oven for all air exposures.

11.6 Following each exposure time period, each set of samples are to be drained of any test liquids, towel dried, and visually examined for damage within 2 h of extraction from the test liquids. Connector pipe fittings and joints shall not be removed or reassembled before repeating of Physical Abuse Tests per 11.7 are conducted.

11.7 Following each exposure time period, after the exposure sample preparation and visual exam, described in 11.6, and within 16 to 32 h after extraction from the test liquids, Physical Abuse Tests, followed by Leakage Tests per 6.2, and Breakdown Tests per 6.4, are to be conducted at lab temperature only. The physical abuse tests shall be conducted on the samples as follows:

a) Tension Test per 8.7, on sample 1;

b) Compression Test per 8.8, on sample 2; and

c) Bending Test per 8.9, on sample 3.

11.8 Following the test sequence, each sample shall not leak after pressurizing. The breakdown pressure values of each sample shall be at least 250 psig (1725 kPa) for primary and/or 200 psig (1380 kPa) for secondary, with an average of at least 10 times the rated pressure, or 70 % of the as received breakdown pressure.

11.9 Following the exposures, there shall be no severe corrosion or excessive loss of protective coatings.

12 Fire Test

12.1 One 3 ft (914 mm) sample of all connector pipe types in worst case sizes shall be subjected to the hydrocarbon pool fire described in 12.2 through 12.4 for 30 min (aboveground rated) or 15 min (sump rated) while filled with water at rated pressure. A repeat of Leakage test per 6.2 shall then be conducted.

12.2 The sample shall be capped/plugged at one end and connected to a metal pipe or tube with a shutoff valve, pressure gauge, pressure regulator or equivalent means at the other end to maintain the rated pressure throughout the fire exposure. The sample shall then be centered and supported 4 in (100 mm) above the rim of a steel liquid-tight fire pan, approximately 20 in (500 mm) ID by 6 in (150 mm) deep, so that one end fitting, and joints and at least 1/2 of the pipe length, or 20 in (500 mm), whichever is longer, is exposed to the flame.

12.3 After the sample is positioned and pressurized, 1 US gal (3.8 L) of commercial grade kerosene (K1) shall be ignited in the fire pan, followed by additional amounts of kerosene, as needed, to maintain the fire for 30 min. Water may be used as a buffer for the delivery of additional kerosene through a metal tube at the bottom of the pan with a control system. The pressure shall be monitored with water adjusted and/or steam removed as needed to maintain the pressure within ±5 % of the rated value.

12.4 When the test reaches the required time, the fire shall be extinguished using an appropriate method that does not damage the sample. After cooling to lab temperature, the sample shall be visually examined for damage before repeat leak testing.

12.5 The samples shall not leak during the fire test or after the repeat leakage test.

13 Interstitial Communication Test

13.1 A minimum 6 ft (1.83 m) length of the pipe types below in worst case sizes and fittings with respect to minimum interstitial space, shall be subjected to the test described in 13.2 to measure the communication rate. A 90° elbow on one end shall be used to add the test liquid.

a) Field-use combinations of primary and secondary connector pipe; and

b) Coaxial connector pipes.

Exception: Connector pipes with a continuous interstitial space of at least 0.10 in (2.5 mm) between primary and secondary pipe walls and fittings are exempt.

13.2 The sample on a flat surface shall be bent to the minimum rated radius, with water added to the interstitial space at the elbow with a hydrostatic head not exceeding 6 in (152 mm). The time between introduction and exit of the test liquid at opposite ends of the pipe shall be measured.

13.3 The calculated communication rate (distance/time) shall not be less than 2 ft/h (63 cm/h).

MANUFACTURING AND PRODUCTION TESTS

14 General

14.1 All connector pipe and components shall be subjected to material, process, construction, and performance checks by the manufacturer to adequately control the quality of the products. Material checks shall include pre-process acceptance of raw materials and post process evaluations of critical properties. Process checks shall include process parameters (such as time, temperature, pressure, or other machine settings). Details of the manufacturer's quality control program shall be documented.